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Stillhouse Hollow Reservoir Bell County, Texas

National Eutrophication Survey, Corvallis, Oreg

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16. ABSTRACT

Annual total phosphorus and total nitrogen loadings to the lake were estimated and subdivided according to either point or non-point source origin. An assessment of the lake's trophic condition and limiting nutrient is also provided. All data collected by the U.S.E.P.A. National Eutrophication Survey during the one year study of the lake and its tributaries are included in the report.

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REPORT

ON

STILLHOUSE HOLLOW RESERVOIR

BELL COUNTY

TEXAS

EPA REGION VI

WORKING PAPER NO. 661

WITH THE COOPERATION OF THE

TEXAS WATER QUALITY BOARD

AND THE

TEXAS NATIONAL GUARD

MARCH, 1977

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FOREWORD

The National Eutrophication Survey was initiated in 1972 in response to an Administration commitment to investigate the nationwide threat of accelerated eutrophication to freshwater lakes and reservoirs.

OBJECTIVES

The Survey was designed to develop, in conjunction with state environmental agencies, information on nutrient sources, concentrations, and impact on selected freshwater lakes as a basis for formulating comprehensive and coordinated national, regional, and state management practices relating to point-source discharge reduction and non-point source pollution abatement in lake watersheds.

ANALYTIC APPROACH

The mathematical and statistical procedures selected for the Survey's eutrophication analysis are based on related concepts that:

a. A generalized representation or model relating sources, concentrations, and impacts can be constructed.

b. By applying measurements of relevant parameters associated with lake degradation, the generalized model can be transformed into an operational representation of a lake, its drainage basin, and related nutrients.

c. With such a transformation, an assessment of the potential for eutrophication control can be made.

LAKE ANALYSIS

In this report, the first stage of evaluation of lake and watershed data collected from the study lake and its drainage basin is documented. The report is formatted to provide state environmental agencies with specific information for basin planning [§303(e)], water quality criteria/standards review [§303(c)], clean lakes [§314(a,b)], and water quality monitoring [§106 and §305(b)] activities mandated by the Federal Water Pollution Control Act Amendments of 1972.

Beyond the single lake analysis, broader based correlations between nutrient concentrations (and loading) and trophic condition are being made to advance the rationale and data base for refinement of nutrient water quality criteria for the Nation's fresh water lakes. Likewise, multivariate evaluations for the relationships between land use, nutrient export, and trophic condition, by lake class or use, are being developed to assist in the formulation of planning guidelines and policies by EPA and to augment plans implementation by the states.

ACKNOWLEDGEMENT

The staff of the National Eutrophication Survey (Office of Research & Development, U. S. Environmental Protection Agency) expresses sincere appreciation to the Texas Water Quality Board for professional involvement, to the Texas National Guard for conducting the tributary sampling phase of the Survey, and to those Texas wastewater treatment plant operators who voluntarily provided effluent samples.

Hugh C. Yantis, Jr., Executive Director of the Texas Water Quality Board, and John B. Latchford, Jr., Director, and the staff of the Field Operations Division provided invaluable lake documentation and counsel during the Survey, reviewed the preliminary reports, and provided critiques most useful in the preparation of this Working Paper series.

Major General Thomas Bishop, the Adjutant General of Texas, and Project Officer Colonel William L. Seals, who directed the volunteer efforts of the Texas National Guardsmen, are also gratefully acknowledged for their assistance to the Survey.

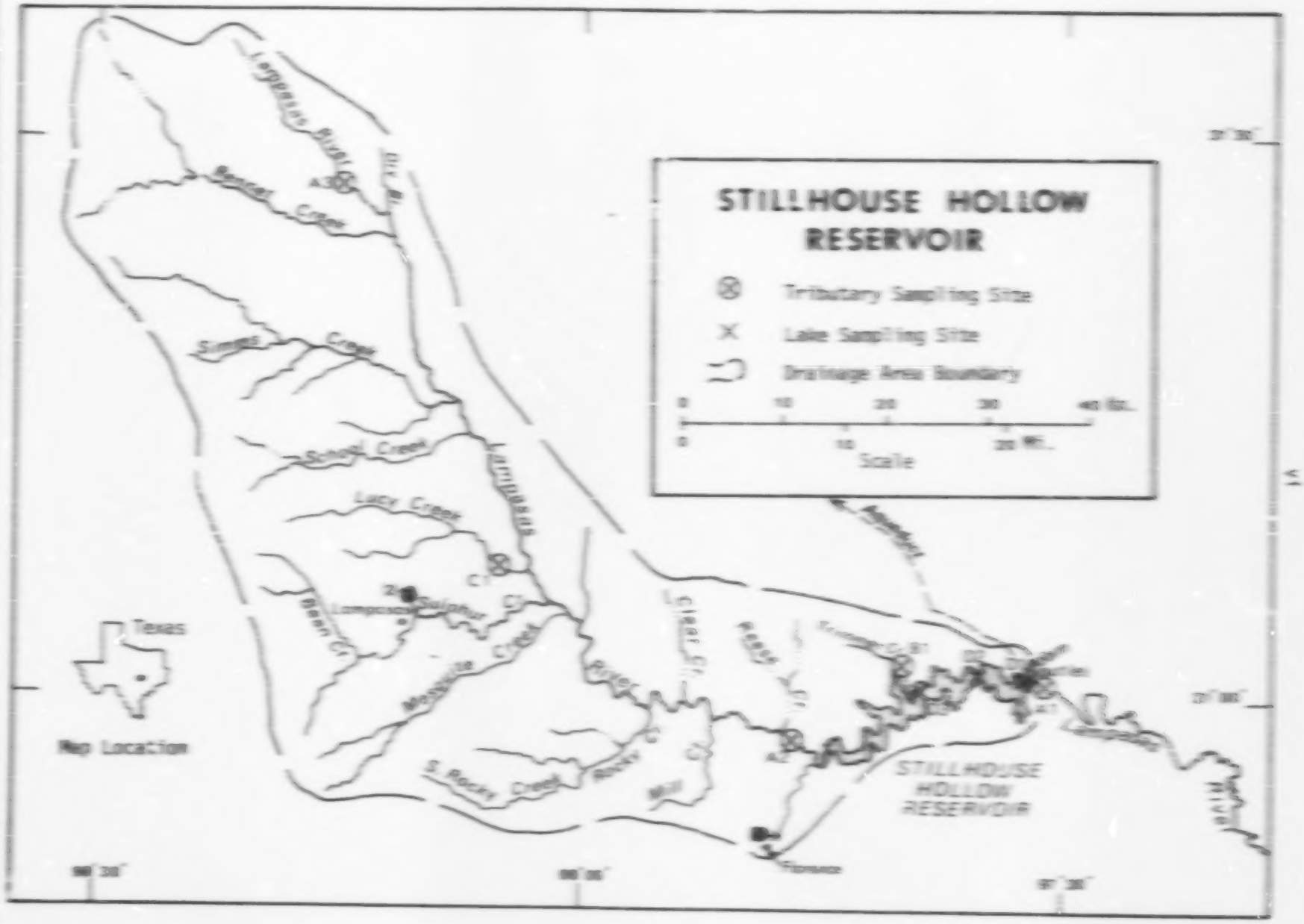
NATIONAL EUTROPHICATION SURVEY

STUDY RESERVOIRS

State of Texas

NAME	COUNTY
Amistad	Val Verde
Bastrop	Bastrop
Belton	Bell, Coryell
Braunig	Bexar
Brownwood	Brown
Buchanan	Burnet, Llano
Caddo	Harrison, Marion, TX; Caddo Parish, LA
Calaveras	Bexar
Canyon	Comal
Colorado City	Mitchell
Corpus Christi	Jim Wells, Live Oak, San Patricio
Diversion	Archer, Baylor
Eagle Mountain	Tarrant, Wise
Fort Phantom Hill	Jones
Houston	Harris
Kemp	Baylor
Lake O'The Pines	Camp, Marion, Morris, Upshur
Lavon	Collin
Lewisville (Garza-Little Elm)	Denton
Livingston	Polk, San Jacinto, Trinity, Walker

Lyndon B. Johnson	Burnet, Llano
Medina	Bandera, Medina
Meredith	Hutchinson, Moore, Potter
O. C. Fisher (San Angelo)	Tom Green
Palestine	Anderson, Cherokee, Henderson, Smith
Possum Kingdom	Palo Pinto, Stephens, Young
Sam Rayburn	Angelina, Jasper Nacogdoches, Sabine, San Augustine
Somerville	Burleson, Lee, Washington
T. V. Spence	Coke
Stamford	Haskell
Stillhouse Hollow	Bell
Tawakoni	Hunt, Rains, Van Zandt
Texoma	Cooke, Grayson TX; Bryan, Johnston, Love, Marshall, OK
Travis	Burnet, Travis
Trinidad	Henderson
Twin Buttes	Tom Green
White River	Crosby
Whitney	Bosque, Hill
Wright Patman (Texarkana)	Bowie, Cass


STILLHOUSE HOLLOW RESERVOIR
Tributary Sampling Site
Lake Sampling Site
Drainage Area Boundary
Scale
Texas
Map Location
Lampasas River
Special Creek
Simms Creek
School Creek
Lucy Creek
Sulphur Cr.
Bear Cr.
Mosquito Creek
S. Rocky Creek
Rocky Creek
Clear Fork
Reese Creek
Owl Creek
Lampasas
STILLHOUSE HOLLOW RESERVOIR

STILLHOUSE HOLLOW RESERVOIR

STORET NO. 4831

I. CONCLUSIONS

A. Trophic Condition:

Survey data indicate that Stillhouse Hollow Reservoir is mesotrophic; i.e., moderately supplied with nutrients and moderately productive. Whether nutrient enrichment is beneficial or deleterious depends on the actual or potential effect on the uses of the reservoir. In this regard, no nuisance conditions are known to personnel of the Texas Water Quality Board and there is little or no impairment of the designated beneficial uses of this water body.

Although it ranked twelfth in overall trophic quality when the 39 Texas reservoirs sampled in 1974 were compared using a combination of six water quality parameters*, the reservoir is phosphorus limited. If inorganic nitrogen is omitted, Stillhouse Hollow Reservoir ranks eighth in overall quality.

Four of the reservoirs had less and one had the same median total phosphorus, 18 had less and one had the same median dissolved orthophosphorus, 24 had less and one had the same median inorganic nitrogen, three had less mean chlorophyll *a*, and five had greater mean Secchi disc transparency. Marked depression or depletion of hypolimnetic dissolved oxygen occurred at sampling stations 1 and 2 in May and August, and depression with depth occurred at station 3 at those times.

* See Appendix A.

Survey limnologists noted small patches of submerged macrophytes in the shallows at stations 2 and 3 in August.

B. Rate-Limiting Nutrient:

The algal assay results indicate that Stillhouse Hollow Reservoir was phosphorus limited at the time the sample was collected (03/13/74). The reservoir data indicate phosphorus limitation at all sampling times.

C. Nutrient Controllability:

1. Point sources--During the sampling year, estimated point-source phosphorus loads accounted for over 66% of the total input to Stillhouse Hollow Reservoir. The two wastewater treatment plants at Lampasas collectively contributed an estimated 59.2%, and the facility at Florence contributed an estimated 7.1%.

The present phosphorus loading of 0.37 g/m^2/year is less than that proposed by Vollenweider (Vollenweider and Dillon, 1974) as a eutrophic loading but more than his oligotrophic loading (see page 14). Because the reservoir is phosphorus limited, elimination or reduction of point-source phosphorus inputs could be considered a measure to maintain good water quality.

2. Non-point sources--Non-point sources contributed about 34% of the total phosphorus load during the sampling year. The Lampasas River contributed 24.8%, and the ungaged minor tributaries and immediate drainage contributed an estimated 4.2% of the total.

The phosphorus export rate of the Lampasas River was less than 1 kg/km^2 during the sampling year (page 13).

II. RESERVOIR AND DRAINAGE BASIN CHARACTERISTICS[1]

A. Morphometry[11]:

1. Surface area: 26.02 kilometers^2.

2. Mean depth: 11.3 meters.

3. Maximum depth: 31.1 meters.

4. Volume: 290,740 x 10^3 m^3.

5. Mean hydraulic retention time: 1 year (based on 1972-1976 mean outflow).

B. Tributary and Outlet:
(See Appendix C for flow data)

1. Tributaries -

Name	Drainage area (km^2)[111]	Mean flow (m^3/sec)[111]
Lampasas River	3,105.4	7.510
Minor tributaries & immediate drainage -	282.2	0.750
Totals	3,387.6	8.260

2. Outlet -

Brazos River Authority diversion	-	0.704*
Lampasas River	3,413.6**	6.270
Total	3,413.6	6.974

C. Precipitation***:

1. Year of sampling: 89.1 centimeters.

2. Mean annual: 86.4 centimeters.

[1] Table of metric conversions--Appendix B.
[11] At conservation pool level; Barrows, 1977.
[111] For limits of accuracy, see Working Paper No. 175, "...Survey Methods, 1973-1976".
* Hall, 1976.
** Includes area of reservoir.
*** See Working Paper No. 175.

III. WATER QUALITY SUMMARY

Stillhouse Hollow Reservoir was sampled four times in 1974 by means of a pontoon-equipped Huey helicopter. Each time, samples for physical and chemical parameters were collected from a number of depths at three stations on the reservoir (see map, page vi). During each visit, a single depth-integrated (4.6 m to surface) sample was composited from the stations for phytoplankton identification and enumeration; and during the first visit, a single 10.9-liter depth-integrated sample was composited for algal assays. Also each time, a depth-integrated sample was collected from each of the stations for chlorophyll a analysis. The maximum depths sampled were 31.1 meters at station 1, 25.6 meters at station 2, and 12.2 meters at station 3.

The sampling results are presented in full in Appendix D and are summarized in the following table (the August nutrient samples were not properly preserved and were not analyzed).

[illegible] SUMMARY OF [illegible] CHEMICAL ANALYSES FOR [illegible]
[illegible]

[illegible]	1ST SAMPLING : 3/13/[illegible]			2ND SAMPLING : 5/22/[illegible]			3RD SAMPLING : 8/[illegible]		
	3 SITES			2 SITES			3 SITES		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TEMP (C)	11.4 - 18.8	15.4	16.4	13.1 - 25.9	22.1	24.[illegible]	24.4 - 28.9	25.6	27.2
DISS OXY (MG/L)	6.2 - 8.4	8.3	8.4	6.1 - 1.8	3.0	2.8	6.8 - 7.2	3.4	1.8
CNDCTVY (MICRO)	38[illegible] - 54[illegible]	46[illegible]	48[illegible]	4[illegible] - 9[illegible]	53[illegible]	5[illegible]	43[illegible] - 39[illegible]	55[illegible]	55[illegible]
PH (STAND UNITS)	7.9 - 8.4	8.2	8.3	7.8 - 9.5	8.1	8.4	7.5 - 8.7	8.0	7.9
TOT ALK (MG/L)	16[illegible] - 17[illegible]	172.	178.	14[illegible] - 172.	16[illegible]	16[illegible]	[illegible]	[illegible]	[illegible]
TOT P (MG/L)	0.08[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	0.0[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	[illegible]	[illegible]	[illegible]
DISS P (MG/L)	0.0[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	[illegible]	[illegible]	[illegible]
ORTHO (MG/L)	0.0[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	[illegible]	[illegible]	[illegible]
AMMONIA (MG/L)	0.[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	[illegible]	[illegible]	[illegible]
KJEL N (MG/L)	0.[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	[illegible]	[illegible]	[illegible]
NITR N (MG/L)	0.[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	[illegible]	[illegible]	[illegible]
TOTAL N (MG/L)	0.[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	0.[illegible] - 0.[illegible]	0.[illegible]	0.[illegible]	[illegible]	[illegible]	[illegible]
CHLOPYL A (UG/L)	1.1 - 1.5	1.3	1.3	4.7 - 15.2	9.9	8.6	1.1 - 3.2	2.2	2.4
SECCHI (METERS)	1.8 - 2.7	2.7	2.1	1.1 - 2.4	2.1	2.2	2.2 - 5.2	3.5	3.4

[illegible]

[illegible]

[illegible]

PARAMETER	[illegible]	[illegible]	[illegible]
TEMP (C)	21.0 - 22.4	21.4	21.7
DISS OXY (MG/L)	4.2 - 8.6	6.7	6.6
CONDUCTVY (MICROMHO)	724. - 736.	734.	734.
PH (STAND UNITS)	7.4 - 8.2	7.4	7.6
TOT ALK (MG/L)	[illegible]	[illegible]	[illegible]
TOT P (MG/L)	0.019 - 0.024	0.020	0.020
ORTHO P (MG/L)	0.005 - 0.009	0.007	0.008
NO2+NO3 (MG/L)	0.108 - 0.120	0.112	0.113
AMMONIA (MG/L)	0.023 - 0.038	0.029	0.030
KJEL N (MG/L)	0.200 - 0.300	0.250	0.300
INORG N (MG/L)	0.140 - 0.220	0.180	0.200
TOTAL N (MG/L)	0.320 - 0.400	0.380	0.420
CHLRPHYL A (UG/L)	3.7 - 3.7	3.7	3.6
SECCHI (METERS)	6.5 - 2.3	4.2	4.7

B. Biological characteristics

1. Phytoplankton -

Sampling Date	Dominant Genera	Algal Units per ml
03/13/74	1. Chroomonas sp.	940
	2. Elakatothrix sp.	34
	3. Stephanodiscus sp.	34
	4. Nitzschia sp.	34
	5. Gymnodinium sp.	35
	Other genera	32
	Total	1,108
05/21/74	1. Chroomonas sp.	386
	2. Coelastrum sp.	197
	3. Cryptomonas sp.	72
	4. Aphanocapsa sp.	62
	5. Pediastrum sp.	62
	Other genera	67
	Total	846
08/14/74	1. Cyclotella sp.	123
	2. Cryptomonas sp.	91
	3. Oocystis sp.	77
	4. Crucigenia sp.	62
	5. Cosmarium sp.	46
	Other genera	201
	Total	602
11/04/74	1. Chroomonas sp.	394
	2. Cyclotella sp.	219
	3. Cryptomonas sp.	176
	4. Ankistrodesmus sp.	66
	5. Pediastrum sp.	44
	Other genera	110
	Total	1,008

B. Chlorophyll a -

Sampling Date	Station Number	Chlorophyll a (µg/l)
03/13/74	1	1.1
	2	1.3
	3	1.6
05/21/74	1	0.4
	2	4.7
	3	16.2
08/14/74	1	2.2
	2	1.1
	3	3.2
11/04/74	1	2.9
	2	3.2
	3	1.7

C. Limiting Nutrient Study:

1. Autoclaved, filtered, and nutrient spiked -

Spike (mg/l)	Ortho P Conc. (mg/l)	Inorganic N Conc. (mg/l)	Maximum yield (mg/l-dry wt.)
Control	0.005	0.285	0.1
0.050 P	0.055	0.285	2.2
0.050 P + 1.0 N	0.055	1.285	9.5
1.0 N	0.005	1.285	0.1

2. Discussion -

The control yield of the assay alga, Selenastrum capricornutum, indicates that the potential primary productivity of Stillhouse Hollow Reservoir was low at the time the sample was collected (03/13/74). The significant increase in yield

with the addition of orthophosphorus and the lack of change in yield when only nitrogen was added indicate phosphorus limitation.

The reservoir data indicate phosphorus limitation in March, May, and November (i.e., the mean inorganic nitrogen to orthophosphorus ratios were 15 to 1 or greater).

IV. NUTRIENT LOADINGS
(See Appendix E for data)

For the determination of nutrient loadings, the Texas National Guard collected monthly near-surface grab samples from each of the tributary sites indicated on the map (page vi), except for the months of April and May when two samples were collected. Sampling was begun in September, 1974, and was completed in August, 1975.

Through an interagency agreement, stream flow estimates for the year of sampling and a "normalized" or average year were provided by the Texas District Office of the U.S. Geological Survey for the tributary sites nearest the reservoir.

In this report, nutrient loads for sampled tributaries were calculated using mean annual concentrations and mean annual flows. Nutrient loads shown are those measured minus point-source loads, if any.

Nutrient loads in the diversion by the Brazos River Authority were calculated using the mean concentrations in Lampasas River (station A-1) and the total of the 1974 diversion in cubic meters. Nutrient loads for unsampled "minor tributaries and immediate drainage" ("ZZ" of U.S.G.S.) were estimated using the mean concentrations in Trimmer Creek at station B-1 and the mean annual ZZ flow.

The operators of the waste treatment facilities of Lampasas and Florence did not participate; nutrient loads from these sources were

estimated at 1.134 kg P and 3.401 kg N/capita/year, and flows were estimated at 0.3785 m^3/capita/day.

A. Waste Sources:

1. Known municipal -

Name	Pop. Served	Treatment	Mean Flow (m^3/d)	Receiving Water
Lampasas (2 plants)*	6,000	tr. filter	1,892.5	Sulphur Creek/ Lampasas River
Florence**	600	stab. pond	227.1	Unnamed Creek/ Stillhouse Hollow Reservoir

2. Known industrial - None

* Wyatt, 1976.
** Anonymous, 1971.

B. Annual Total Phosphorus Loading - Average Year:

1. Inputs -

Source	kg P/ yr	% of total
a. Tributaries (non-point load) -		
Lampasas River	1,380	24.8
b. Minor tributaries & immediate drainage (non-point load) -	400	4.2
c. Known municipal STP's -		
Lampasas	5,670	59.8
Florence	680	7.1
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	455	4.7
Total	9,585	100.0

2. Outputs -

Lake outlet - Diversion	355
Lampasas River	3,165
Total	3,520

3. Net annual P accumulation - 6,065 kg.

* See Working Paper No. 175.

C. Annual Total Nitrogen Loading - Average Year:

1. Inputs -

Source	kg N/yr	% of total
a. Tributaries (non-point load) -		
Lampasas River	212,960	77.4
b. Minor tributaries & immediate drainage (non-point load) -	15,090	5.5
c. Known municipal STP's -		
Lampasas	17,005	6.2
Florence	2,040	0.7
d. Septic tanks - Unknown	?	-
e. Known industrial - None	-	-
f. Direct precipitation* -	28,090	10.2
Total	275,185	100.0

2. Outputs -

Lake outlet - Diversion	14,475	
Lampasas River	128,920	
Total	143,395	

3. Net annual N accumulation - 131,790 kg.

D. Non-point Nutrient Export by Subdrainage Area:

Tributary	kg P/km²/yr	kg N/km²/yr
Lampasas River	<1	69

* See Working Paper No. 175.

E. Mean Nutrient Concentrations in Ungaged Streams:

Tributary	Mean Total P Conc. (mg/l)	Mean Total N Conc. (mg/l)
Trimmer Creek	0.017	0.630
Lucy Creek	0.023	0.643

F. Yearly Loads:

In the following table, the existing phosphorus loadings are compared to those proposed by Vollenweider (Vollenweider and Dillon, 1974). Essentially, his "dangerous" loading is one at which the receiving water would become eutrophic or remain eutrophic; his "permissible" loading is that which would result in the receiving water remaining oligotrophic or becoming oligotrophic if morphometry permitted. A mesotrophic loading would be considered one between "dangerous" and "permissible".

Note that Vollenweider's model may not be applicable to water bodies with short hydraulic retention times.

	Total Phosphorus		Total Nitrogen	
	Total	Accumulated	Total	Accumulated
grams/m^2/yr	0.37	0.23	10.6	6.1

Vollenweider phosphorus loadings ($g/m^2/yr$) based on mean depth and mean hydraulic retention time of Stillhouse Hollow Reservoir:

"Dangerous" (eutrophic loading)	0.64
"Permissible" (oligotrophic loading)	0.32

2. LITERATURE REVIEWED

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VI. APPENDICES

APPENDIX A

LAKE RANKINGS

LAKE DATA TO BE USED IN ANALYSIS

LAKE CODE	LAKE NAME	[illegible] TOTAL P	[illegible] INORG P	[illegible] SEC	[illegible] CHLOR	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CADDY LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CALAVERAS LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CANYON RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE COLORADO CITY	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	CORPUS CHRISTI LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	EAGLE [illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	FT PHANTOM HILL LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LITTLE ELM RESERVO	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE OF THE PINES	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAVON RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LIVINGSTON LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LYNDON B JOHNSON LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	LAKE [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	PALESTINE LAKE	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] [illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	SAN ANGELO RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible] [illegible] RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	E O SPENCE RESERVOIR	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

| | | |

PERCENT OF LAKES WITH HIGHER VALUES (NUMBER OF LAKES WITH HIGHER VALUES)

LAKE CODE	LAKE NAME	REGION TOTAL P	REGION ZMAX/Z %	MEAN MEAN DEC	MEAN CHLORA	ZT/ZMAX	SECCHI DISC / ZMAX	TRUE COLOR
[illegible]	SUNSHINE LAKE	29 (113)	55 (213)	24 (91)	3 (12)	67 (259)	35 (135)	257
[illegible]	STAMPEDE LAKE	18 (71)	47 (177)	5 (21)	18 (71)	82 (317)	39 (146)	254
[illegible]	STILLWATER [illegible]	69 (333)	37 (141)	67 (333)	47 (254)	17 (61)	54 (199)	372
[illegible]	TAWATINA LAKE	32 (123)	78 (296)	37 (144)	21 (81)	63 (241)	38 (145)	253
[illegible]	TOMAHAWK LAKE	11 (41)	51 (196)	13 (51)	16 (61)	72 (275)	13 (51)	176
[illegible]	TEXOMA LAKE	35 (141)	34 (133)	61 (233)	45 (171)	17 (61)	21 (71)	217
[illegible]	TWINS LAKE	69 (333)	21 (71)	92 (353)	82 (313)	17 (61)	84 (317)	384
[illegible]	THUNDER	8 (31)	42 (223)	11 (41)	5 (21)	92 (353)	8 (31)	189
[illegible]	TWIN BUTTES RESERVOIR	59 (223)	21 (71)	58 (223)	61 (233)	44 (171)	43 (211)	311
[illegible]	WHITE FISH BLUFF RESERVOIR	84 (321)	61 (223)	76 (293)	45 (341)	17 (61)	62 (211)	346
[illegible]	WHITNEY LAKE	62 (241)	51 (193)	76 (321)	71 (271)	17 (61)	76 (291)	357

LAKES RANKED BY INDEX NO.

RANK	LAKE CODE	LAKE NAME	INDEX NO.
29	421	LYNDON B JOHNSON LAKE	259
30	424	TEXOMA LAKE	257
31	429	SPRINGVILLE LAKE	254
32	425	SAN ANGELO RESERVOIR	249
33	433	TOMAHAWK LAKE	175
34	435	NORTH LITTLE BLUE RESERVOIR	173
35	439	TRINIDAD	164
36	446	BRYANS LAKE	159
37	451	CORPUS CHRISTI LAKE	156
38	457	HOUSTON LAKE	139
39	459	LEXINGTON LAKE	95

APPENDIX B

CONVERSION FACTORS

CONVERSION FACTORS

Hectares x 2.471 = acres

Kilometers x 0.6214 = miles

Meters x 3.281 = feet

Cubic meters x 8.107×10^{-4} = acre/feet

Square kilometers x 0.3861 = square miles

Cubic meters/sec x 35.315 = cubic feet/sec

Centimeters x 0.3937 = inches

Kilograms x 2.205 = pounds

Kilograms/square kilometer x 5.711 = lbs/square mile

APPENDIX C

TRIBUTARY FLOW DATA

APPENDIX D

PHYSICAL and CHEMICAL DATA

[illegible]

[illegible]
[illegible]
[illegible]

[illegible]
[illegible]

DATE	TIME	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	01	38	[illegible]	17.4		34	46	8.46	166	8.828	8.388	8.116	8.887
	04	38	[illegible]	17.4	8.8		45	8.48	174	8.823	8.288	8.188	8.812
	06	38	[illegible]	15.6	8.8		47	8.38	165	8.828	8.288	8.116	8.811
	04	38	[illegible]	13.8	8.8		44	8.25	194	8.838	8.288	8.118	8.811
	06	38	[illegible]	12.1	8.8		39	8.15	166	8.858	8.287	8.138	8.808
	08	38	[illegible]	11.9	8.8		46	8.18	167	8.868	8.388	8.138	8.819
[illegible]	12	25	[illegible]	26.1		105	54	8.58	147	8.843	8.568	8.868	8.889
	12	25	[illegible]	25.4	7.8		53	8.54	146	8.838	8.288	8.838	8.888
	12	25	[illegible]	23.6	8.8		50	8.58	162	8.848	8.288	8.166	8.886
	12	25	[illegible]	17.7	2.4		47	7.85	184	8.846	8.288	8.258	8.885
	12	25	[illegible]	13.6	2.8		46	7.72	185	8.842	8.286	8.288	8.888
	12	25	[illegible]	13.1	2.8		46	8.25	185	8.844	8.288	8.298	8.885
[illegible]	04	35	[illegible]	28.5	8.8	84	58	8.58					
	06	35	[illegible]	28.8	8.8		53	8.68					
	08	35	[illegible]	27.2	7.2		58	8.88					
	10	35	[illegible]	24.9	8.8		43	7.48					
	12	35	[illegible]	20.7	8.8		45	7.48					
	14	35	[illegible]	15.3	8.8		43	7.48					
	16	35	[illegible]	14.4	8.8		43	7.78					
[illegible]	12	38	[illegible]	21.9	7.8	48	7263	8.38	132	8.828	8.388	8.128	8.886
	13	38	[illegible]	22.8	7.8		7258	8.34	131	8.829	8.388	8.128	8.887
	13	38	[illegible]	21.4	7.8		7248	8.36	138	8.828	8.288	8.128	8.887
	13	38	[illegible]	20.4	7.8		7249	7.46	131	8.828	8.388	8.136	8.887
	12	38	[illegible]	20.7	7.8		7247	7.34	128	8.829	8.388	8.168	8.868
	13	38	[illegible]	21.4	7.2		7246	7.36	138	8.828	8.288	8.288	8.828

* VALUE FROM TO BE
LESS THAN INDICATED

[illegible] MECHANICAL INTEGRITY [illegible]

[illegible]
[illegible]
[illegible]
[illegible]

[illegible]
[illegible]

DATE	TIME	DEPTH	ANNUL PRESSURE	TUBING PRESSURE	CASING INTEGRITY
FROM	OF			&	[illegible]
TO	DAY	FEET	PSIG	PSIG	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
[illegible]	[illegible]	[illegible]		[illegible]	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		
	[illegible]	[illegible]	[illegible]		

[illegible] VALUE KNOWN TO BE
LESS THAN [illegible]

[illegible]

[illegible]
[illegible]
[illegible]

[illegible]
[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
7-[illegible]	10	10	[illegible]	18.1		34	46	5.45	259	0.838	0.288	0.110	0.385
	10	10	[illegible]	16.1	5.7		47	6.46	178	0.828	0.287	0.108	0.411
	10	10	[illegible]	17.9	6.8		42	6.48	248	0.825	0.286	0.108	0.411
	10	10	[illegible]	16.4	6.2		45	6.28	171	0.845	0.288	0.129	0.411
	10	10	[illegible]	12.9	6.8		41	6.03	178	0.853	0.488	0.148	0.485
	10	10	[illegible]	12.1	6.2		49	7.45	172	0.188	0.386	0.159	0.818
7-[illegible]	12	05	[illegible]	26.1		65	59	6.55	147	0.858	0.488	0.066	0.889
	12	05	[illegible]	26.1	5.6		57	6.50	146	0.838	0.386	0.858	0.886
	12	05	[illegible]	25.7	6.8		59	7.48	166	0.248	0.286	0.126	0.818
	12	05	[illegible]	21.4	8.6		57	7.73	169	0.841	0.386	0.225	0.889
	12	05	[illegible]	15.6	8.1		46	7.48	171	0.138	0.368	0.188	0.889
	12	05	[illegible]	13.7	7.1		44	7.78	172	0.148	0.488	0.288	0.889
7-[illegible]	18	15	[illegible]	28.9	7.8	29	57	6.58					
	18	15	[illegible]	28.6			58	6.78					
	18	15	[illegible]	27.1	8.6		55	7.48					
	18	15	[illegible]	24.6	8.6		56	7.48					
	18	15	[illegible]	20.4	8.8		55	7.48					
	18	15	[illegible]	16.5	8.8		47	7.78					
	18	15	[illegible]	15.1	8.6		45	7.48					
7-[illegible]	13	10	[illegible]	22.4	7.4	37	72.6	6.64	126	0.838	0.788	0.138	0.485
	13	10	[illegible]	20.3	7.6		72.6	6.13	125	0.838	0.288*	0.128	0.887
	13	10	[illegible]	20.3	8.8		72.6	6.89	122	0.838	0.288	0.128	0.888
	13	10	[illegible]	20.3	7.4		72.6	6.82	121	0.844	0.288	0.128	0.887
	13	10	[illegible]	21.3	5.6		72.6	7.67	96	0.198	0.388	0.128	0.818
	13	10	[illegible]	21.2	6.4		72.6	7.78	122	0.838*	0.288*	0.128	0.812

* VALUE FROM TO BE
LESS THAN INDICATED

[illegible]

[illegible]
[illegible]
[illegible]
[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]
FROM	OF			D	[illegible]
TO	DAY	FEET	[illegible]	[illegible]	[illegible]
[illegible]	10	10	[illegible]	[illegible]	1.3
	10	10	[illegible]	[illegible]	
	10	10	[illegible]	[illegible]	
	10	10	[illegible]	[illegible]	
	10	10	[illegible]	[illegible]	
	10	10	[illegible]	[illegible]	
[illegible]	12	05	[illegible]	[illegible]	4.7
	12	05	[illegible]	[illegible]	
	12	05	[illegible]	[illegible]	
	12	05	[illegible]	[illegible]	
	12	05	[illegible]	[illegible]	
	12	05	[illegible]	[illegible]	
[illegible]	10	35	[illegible]		1.1
[illegible]	13	30	[illegible]	[illegible]	3.7
	13	30	[illegible]	[illegible]	
	13	30	[illegible]	[illegible]	
	13	30	[illegible]	[illegible]	
	13	30	[illegible]	[illegible]	
	13	30	[illegible]	[illegible]	

| | | |

APPENDIX E

TRIBUTARY DATA

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

DATE	TIME	DEPTH	[illegible]	00625	39910	77671	49865
FROM	OF	[illegible]		TOT [illegible]	[illegible]	[illegible]	[illegible]
TO	DAY	FEET	[illegible]	%VOL	%VOL	%VOL P	%VOL A
74/04/02	14	00	[illegible]	0.480	0.823	0.885	0.825
74/10/15	11	00	[illegible]	0.799	0.838	0.810	0.815
74/11/19	11	00	[illegible]	0.380	0.815	0.885	0.810P
74/12/16	11	00	[illegible]	0.700	0.816	0.885	0.822
75/01/21	10	00	[illegible]	0.560	0.824	0.884	0.825
75/02/17	11	00	[illegible]	0.480	0.809	0.810	0.818
75/03/12	10	30	[illegible]	0.760	0.805	0.885	0.828
75/04/09	11	00	[illegible]	0.480	0.825	0.885	0.828
75/04/22	12	00	[illegible]	0.250	0.810	0.810	0.815
75/05/07	11	30	[illegible]	2.500	0.855	0.825	
75/05/29	12	00	[illegible]	0.350	0.815	0.810	0.840
75/06/18	11	00	[illegible]	0.350	0.825	0.885	0.840
75/07/09	11	00	[illegible]	0.450	0.810	0.810	0.840
75/08/12	12	30	[illegible]	0.530	0.827	0.885	0.850

A VALUE KNOWN TO BE
LESS THAN INDICATED

[illegible]

[illegible]

DATE FROM TO	TIME DAY	DEPTH FEET	[illegible] [illegible] TOTAL MG/L	[illegible] TOT M.EL % MG/L	[illegible] TOTAL MG/L	[illegible] [illegible] DIFF MG/L P	[illegible] [illegible] MG/L P
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

[illegible] VALUE [illegible] TO BE
LESS THAN INDICATED

[illegible] RETRIEVAL DATE: 74/12/16

[illegible]
31 12 13.0 097 39 55.0 +
[illegible] CREEK
+8 T.D. [illegible]
[illegible]
[illegible] +0 0405 + 45 30 [illegible]
[illegible] 2032[illegible]
[illegible] FEET [illegible] CLASS 32

DATE FROM TO	TIME OF DAY	DEPTH FEET	[illegible] MG/L	[illegible] TOT +DIS MG/L	[illegible] TOTAL MG/L	[illegible] DRTHO MG/L P	[illegible] MG/L P
74/04/08			0.194	1.200	0.420	0.0054	0.010>
74/10/15	11 45		0.200	0.300	0.317	0.0054	0.005>
74/11/19	11 45		0.420	0.200	0.415	0.005	0.010>
74/12/04	12 00		0.194	0.300	0.424	0.0054	0.010>
75/01/28	11 30		0.266	0.400	0.424	0.0064	0.010>
75/02/17	11 30		0.400	0.400	0.382	0.0054	0.010>
75/03/12	11 30		0.410	0.450	0.365	0.0054	0.010>
75/04/06	12 00		0.245	0.365	0.317	0.0054	0.010>
75/04/22	13 00		0.200	0.300	0.425	0.0054	0.010>
75/05/07	12 30		0.250	0.300	0.420	0.0054	0.020
75/05/29	13 00		0.240	0.220	0.410	0.0054	0.005
75/06/16	12 00		0.130	0.260	0.310	0.0054	0.010
75/07/09	12 00		0.170	0.260	0.415	0.0054	0.010>
75/08/12	13 30		0.125	0.400	0.325	0.0054	0.010

< VALUE GIVEN IS AT
LESS THAN DETECTED

[illegible]

[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]
[illegible]

DATE	TIME	DEPTH	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
FROM	OF		NITROGEN,	N	TOTAL	ORTHO	
TO	DAY	FEET	MG/L	MG/L	MG/L	MG/L P	MG/L P
[illegible]	12	10	0.424	0.488	0.085	0.0054	0.415
[illegible]	09	40	0.340	0.388	0.019	0.0054	0.3859
[illegible]	10	00	0.272	0.360	0.029	0.0059	0.0104
[illegible]	09	30	0.249	0.405	0.016	0.0054	0.046
[illegible]	09	30	0.269	0.509	0.016	0.0049	0.0104
[illegible]	10	00	0.352	0.406	0.016	0.0044	0.0107
[illegible]	09	30	0.288	0.408	0.0054	0.0054	0.0117
[illegible]	10	00	0.123	0.288	0.015	0.0054	0.0107
[illegible]	11	30	0.095	0.286	0.025	0.0054	0.0104
[illegible]	10	00	0.268	0.756	0.096	0.018	0.0492
[illegible]	11	00	0.095	0.288	0.018	0.0054	0.056
[illegible]	09	30	0.135	0.259	0.018	0.0054	0.029
[illegible]	09	30	0.135	0.291	0.018	0.0054	0.0104
[illegible]	10	30	0.268	0.388	0.038	0.0059	0.038

[illegible]
[illegible]